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A BRIEF RÉSUMÉ OF INVESTIGATIONS MADE IN 1913 ON TROGODERMA INCLUSA (COLEOPTERA).....*Adolph H. Beyer.*

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A Brief Resume of Investigations Made in 1913 on *Trogoderma inclusa* Lec. (a Dermestid).

By ADOLPH H. BEYER.

THE work herewith reported was undertaken at the suggestion of Prof. S. J. Hunter, who had received complaints concerning damage to leather horse collars. The damage consisted in more or less numerous perforations of the leather by some insect, which injury interfered seriously with the marketability of the manufactured goods. It became my task to determine the insect causing the damage, the source of infestation, and the methods of controlling the pest. The investigations were made in 1913, but are reported here for the first time.

NATURE OF THE INJURY TO THE HORSE COLLARS.

The leather of the infested collars has the appearance of being perforated with numerous little round holes about the size of a pinhead. The insects reared from infested collars proved to be dermestid beetles belonging to the above-named species. The insects hatch in the rye straw used in filling the collars, and the larvæ live upon the grain left in the straw. As the larvæ develop to within a month of the adult stage, they approach the outside of the collar and emerge by eating holes through the leather of the collar.

A number of firms engaged in the manufacture of collars have reported damage of this character. One firm in Texas writes: "We wish to state that five or six years ago we had trouble of this kind owing to the fact that we were using rye straw with lots of grain still in the straw, and small worms or insects would bore through the leather into the collar to get at the grain. We had very little loss, as we soon found out the trouble, and therefore quit using straw that had any grain in it at all."

Two or three firms securing straw from a grower near Lawrence, Kan., reported serious trouble. An examination of one factory revealed fifty per cent of the collars infested. Upon examining the floor, walls and window and door casings, the cracks were found to contain many adult beetles, which in all cases were dead. The light and heat of the sun had a marked influence upon the distribution and development of the insects, as the collars near the south windows were more seriously damaged, the injury decreasing gradually as one neared the north side of the building.

SOURCE OF INFESTATION.

Since injury was reported from manufacturers using straw grown near Lawrence, Kan., it appeared possible that the straw might have been infested before it was shipped to the factories. An investigation was made first at the ranch where the rye straw was grown. It was found that the sheaves were stacked up in the barns to conserve the value of the straw for collar-stuffing purposes, and during the winter months a specially made thresher was used in removing the grain from the head of the sheaf without cutting the band. After the rye bundles were threshed they were baled, being compressed and tied with wire ready for shipping to the collar factory. I found no trace of the insect about any part of the sheaves. They were apparently free in every respect from the insect. I also examined the threshed bundles before they were baled, and noticed that there was considerable grain left in the straw, which later afforded food for the development of the insects in the collar. I next examined the threshed rye in the bin, thinking perhaps the insects might be hibernating at this season of the year. I collected several quarts of the rye in a screw-sealed glass jar, to keep out other infestations, and took this, with one of the rye sheaves, to the laboratory.

I placed some of the rye straw taken from the sheaf in a large glass-enclosed cylinder. This was placed in the incubator at ordinary room temperature of 70° F. I recorded the temperature each day and watched for the development of infestations, but noted no development of life for several weeks. At the end of three weeks I found two species of grain weevil and several parasites, which I removed from the jar and placed in separate vials. At the end of the fourth week I removed from the jar five specimens of larvæ, apparently of the same species of Dermestidæ that was the cause of the collar infestation. April 15, the adults emerged from the pupæ cases. I found them to be the same species as those causing the damage to the collars.

EXTENT OF INFESTATION.

As stated before, fifty per cent of the collars in one factory were damaged. I made a careful dissection of both sides of a badly infested collar by removing the leather of the facing of the collar. I have found only the larval stage of the life cycle in the collars so far examined. I made an approximate count of all the larvæ found in this collar, and 900 larvæ was the result. I also counted the number of holes in the same collar leather, to get the per cent of damage done by each insect. The actual number of holes in this collar made by this pest was 424. Approximately 1,324 of the insects infested this collar.

The larvæ varied from 2½ to 5 mm. in length. They were usually found in the heads of the rye, or eating on the scattered grains. The larvæ eat straight across the ends or sides of the grain, something as a mouse gnaws, and not after the fashion of the grain borers. Wherever the tunneling or eating process was found, I also found evidence of molting. I found small larvæ emerged in heads of rye, which is evidence that the eggs had been laid in the heads.

LIFE HISTORY OF THE BEETLE.

In making dissections of the collars which had been incubated at a constant temperature of 70 degrees for several weeks, I found various sizes of larvæ and a number in the pupal state. None was found in the adult state. No eggs were found in the collar dissections.

MATING AND OVIPOSITION.

The beetles I found in all cases mated a day or two after emerging from the pupal skins. The eggs varied in number from ten to fifty. They were placed around indiscriminately on the bottoms of Petri dishes from four to six days after copulation. In a number of cases the female oviposited on the rye placed in the dishes, and the eggs adhered to the rye by means of little filaments projecting from one end of the egg. The young larvæ hatched from eight to twelve days later at ordinary room temperature. The young larvæ, soon after hatching, began to feed on the material at hand. They did not wander unless food was scarce or poor. I reared them entirely upon rye grain. The growth of the larvæ depends to a considerable extent upon temperature and the abundance of food, and it is retarded by weather and scarcity of nourishment. The foregoing factors are not, however, the only causes of slow development. I noted in my experiments that the growth of specimens varies

under identical external conditions. Very often a number of the specimens attain full size, metamorphose, and produce young long before others of the same generation. The majority, however, mature in about five months.

THE EGG.

The eggs are about ½ mm. in length and about ⅙ mm. in width. They are oblong in shape and slightly arched. Not uncommonly they were found adhered together in pairs. One end of the egg usually has hair or threadlike projections. Each egg has a number of ridges running lengthwise and crosswise (see plate XL). The eggs are whitish in color, translucent, and the surface appears rough, and is of delicate skin covering the aqueous interior. It is easily broken. The filaments described at the end of the egg adhere to any object with which they come in contact.

MOLTING.

I found without exception that there is much variation in the rate of molting and the number of larval skins shed by the different individuals of this species. Under normal conditions the larvæ molt twice in about every two weeks. Many peculiarities are worthy of mention. The same specimen often sheds its skin irregularly, sometimes within ten days, and again, under the same conditions, not until a period of three or four weeks has lapsed. The rapidly growing individuals molt more frequently than do those which have about attained their full size. The specimens that are slow in development molt less frequently than do the larvæ which develop at the average rate. The full-grown larvæ previously spoken of, which continue to live for a long time before entering the pupal stage, have a decidedly slow rate of molting. The average rate is about once in every three weeks, and there is a gradual decrease as the specimen grows older.

Thus I have found in all my observations that the number of molts is by no means constant. As previously mentioned, the majority of specimens which complete their life history in about five months, shed their skins from ten to fifteen times, whereas many of the individuals with the prolonged larval history molt as often as twenty times.

The larvæ never eat their own skins, nor the skins of other individuals of this species, even though they may be in the most extreme stage of starvation. This was conclusively proven by placing specimens in a glass vial for the purpose of starving the larvæ, and after

several months of starvation, during which the larvæ had molted several times, the skins were never attacked. This fact was also proven in the collar dissections which I made. In one collar in particular, which had been kept in stock for three years after the infestation was noticed, nearly all of the rye seed had been devoured, and the straw and inner surface of the collar were literally full of molted skins, and a large percentage of the larvæ had escaped from the collar.

Just before molting the specimens become inactive, and a break appears in the larval skin along the median dorsal line. This extends from the head along the thorax and partly down the abdomen (see plate XL). The larva assumes a semicircular position, which permits the extrication of the thorax and the head. The legs are then pulled out of their covering, and the light-colored larva crawls out of the exuvia. Its soft covering soon hardens and becomes chitinous, and within a few hours assumes the natural yellowish-brown color.

PUPATION.

When the larva reaches full growth the pupa begins to form within the last larval skin. This is noticeable by the size, shape and the lack of movement or locomotion. The pupa is slightly shorter, larger in diameter, and apparently makes no movements. Four or five days later the skin splits down the median dorsal line and the light-yellowish pupa is exposed. The period of molting lasts from ten to twenty days at ordinary room temperature. When the insects are fully developed they emerge through the large dorsal opening of the pupal skin. Should a specimen be forced out of the larval case when not fully matured, though capable of locomotion, it invariably returns to its former position within the protective larval skin upon coming in contact with it. The pupæ upon emerging are of a whitish color; then comes the darkening of the hair on the thorax and elytra. In three or four days the thorax and elytra take on a reddish color, commencing at the thorax and shading back. The female remains in the pupa case a day or two longer than the male. The average life of the adult is about eighteen days.

FOOD HABITS.

I have found that this species can subsist upon a large variety of substances. In considering the relative value of some of the substances as food for the larvæ, I found that the pest apparently thrives best on cereals. As was formerly stated, the larvæ were, in their natural state, in almost every instance found living on the

grain in the horse collars. Where the grain was most abundant I found the largest percentage of larvæ. In wandering in search of food many holes were made through the straw, upon which they fed in the meantime; and upon coming in contact with the inner surface of the leather, holes about the size of a pinhead were made, through which they emerged, thus injuring the salability and market value of the leather goods. I placed a number of the specimens, soon after they were hatched, on a leather diet, and I found they did not eat at all.

Mr. J. E. Wodsedalek (1912), says with reference to the species *Trogoderma tarsale:*

"A number of the specimens were placed on a feather diet, and although they are now two years old, they have grown but very little. When they were one year old they were very little larger than the newly hatched individuals, and at the end of the second year of life they reached a meager size equal to that which specimens fed on insects ordinarily attain in two weeks. Their development on wool is even slower."

F. H. Chittenden (1897) states:

"One jar of flaxseed from the museum department is infested chiefly by this common museum pest. Many of the larvæ may be seen through the glass, and large patches of their yellowish-brown gnawings and excrement show whene they have been at work. In castor beans a few were present.

"That this species of *Trogoderma* can subsist on a vegetable diet is as positive as it is surprising. No other Coleoptera, to my knowledge, live on oil seeds, and I had nearly arrived at the conclusion that this form of matter was the nearest approach to animal food available, and that these insects could only thrive on such vegetable substances as contain a considerable portion of oleaginous matter. Judge my astonishment when a few weeks after the discovery of the *Trogoderma* living in oil seeds, Doctor Howard brought me a box nearly full of cayenne pepper in which were several *Trogoderma* larvæ. The most careful search failed to show even a fragment of that well-known red pepper pest, *Sitodrepa panicea,* or of any other insect than the Dermestidæ. Subsequently the adult was reared and proved to be *Trogoderma tarsale.*

"To ascertain whether this species would breed on so pungent a substance as cayenne pepper, a few adults were confined with a quantity of this condiment. In due time larvæ appeared, and when examined, August 20, or nearly ten weeks from the time the eggs were deposited, were in vigorous condition, the average individual measuring a tenth of an inch in length, or about half that of the full-grown larvæ. Toward the end of September, while passing through the museum of this department, my attention was attracted by an accumulation of powder and dust about the edges of an exhibit of peanut oil cake, and another of Indian-turnip bulbs. A large number of the larvæ and their cast skins were found under the cakes, also in the flour and meal prepared from peanuts. The Indian-turnip bulbs were very old and dry, and might have been on exhibition twenty years or more.

"When this insect infests a substance of similar color and consistency to flour and meal, only a few larvæ are sufficient, on account of their extraordinary habit of frequently molting, to occasion alarm. In fact, appearances are much worse than the reality. Thus in a small jar of peanut meal in which these larvæ had taken up their abode, about forty larval skins had accumulated when examined September 27, completely covering one-half of the surface of the meal, and giving the impression of a whole colony of insects.

"While the division of entomology was moving into new quarters a bag of Saskatchewan spring wheat, formerly kept in stock for distribution, and described on the label as a hard, amber variety with an exceedingly heavy grain, was unearthed, in which the larvæ of this insect was living, three being present and no other insects except a colony of *Anthrenus* and a single stray *Silvanus*. In fact, this grain is so hard and flinty that weevils would not flourish on it. Soon afterwards I found larvæ in another lot of wheat infested with *Silvanus* and in corn containing *Calandra oryza* and other small beetles. About the same time, Mr. Frank Benton brought me some larvæ found in beehives, where they apparently fed upon propolis in bee glue. There are several recorded instances of *Dermestes lardarius* feeding upon wax, or, more properly speaking, honeycombs, and it is therefore fairly certain that *Trogoderma* has the same habit, although not previously reported in beehives.

"Among the divisional notes I find one recording the receipt of six larvæ of this species in a box of red pepper from a correspondent in Utah, November 22, 1882. These larvæ were kept in a box of red pepper for a year, at which time fifty-four cast skins were noticed. The box was examined January 14, 1887, or over four years from the time of its receipt, when two larvæ and seventy more cast skins were found, but no trace of beetles, although it had been kept closed so that it was impossible for either larvæ or adults to escape. It is very obvious that four larvæ, or the beetles that developed from them, had died in the interim and were devoured by their fellows. In any case, the adult was not reared, and no published statement was made of the larvæ having been found living in the condiment.

"The capability of this species breeding in other seeds was demonstrated by the discovery of the larvæ living upon 'kolu,' an edible leguminous seed somewhat resembling a cowpea. The insect had evidently been first attracted by the dead bodies of the original inhabitants of the seeds, the weevil, *Bruchus chinensis*, but had afterward fed upon the seeds, even hollowing them out and leaving only the empty shells. In a similar manner, larvæ were found, together with those of *Attagenus*, in millet and pumpkin seeds that had formerly been inhabited by the polyphagous Indian meal moth, *Plodia interpunctella*.

"In the case of the six larvæ found in the red pepper, it is not likely that four of them metamorphosed, because if they had it is certain they would have been devoured by their fellows. The hard, chitinous covering and the elytra are never completely devoured, even by starving specimens. It is much more probable that they died in the larval stage, and were later devoured by the other two larvæ, or they might have shriveled up and darkened, and were thus easily overlooked. That the two larvæ which were present four years later were two of the original six is highly probable. There are several larvæ in our laboratory which were obtained three years ago, when they were full grown, and they have not changed any since."

BEHAVIOR.

Naturally the larvæ manifest a strong negative reaction to light, and make effort immediately after hatching and when disturbed to seek a shaded or other place of concealment. If placed near a light or window they soon begin to crawl away from the light. It is also quite noticable when the specimens are placed in a dark room and a strong light is introduced at one end of the glass dish container. This negative phototactic reaction persists throughout life. It is at its highest sensibility to light just before pupation. Thus pupæ are most frequently found in shaded or dark places which afford them a favorable means of protection. The adults, both male and female, retain their negative reaction to light after emerging from their pupal skins. During the period of sexual excitment which follows a day or two later, the insects are still negative, and the females remain decidedly so until their eggs are safely deposited. Several hours or a day after egg-laying, they gradually become indifferent to light, and finally a complete reversal of their former reaction follows. The males also become positively phototactic during the last days of their lives. The larvæ of all stages feign death upon being disturbed. However, when disturbance is continued from a few seconds to a minute at the most, they no longer respond in the same manner. When disturbed the adult insects make themselves very compact by drawing thorax up close to the rest of body. The head is drawn upward and under the thorax, legs and antennæ are folded up, and death is feigned a considerably longer time than in the larval state. The average feint lasts from one to ten minutes

VARIATION IN SIZE.

The adult male insects are smaller, as a general rule, than the female insects, but the small individuals are not always males. There is much variation in the size of the adults. They are from 1.5 mm. to 4 mm. in length, the width also being proportionate. It is difficult to determine the exact cause for this variation in size. Poor nutrition evidently has effect upon the size. However, small individuals appear among the large ones which have lived under very favorable conditions. I noted marked variations in the size of the different larvæ of the same brood within a day or two after hatching. I observed the fact, however, that the small, slowly developing larvæ do not always produce small adults.

ADAPTATION TO FOOD SUPPLY.

An interesting phase of the study of the life history was the extremely long period of time the larvæ can sustain themselves without food. I placed forty larvæ in Petri dishes, ten representative stages, varying from newly hatched to full-grown individuals, without any food whatsoever, for the purpose of determining the period required to produce starvation. I also added a number of Petri dishes, each containing one larva ranging from 1 to 6 mm. in length, and another Petri dish was added, containing a number of a definite size, to determine whether they would eat their skins or not. Measurements were made of all the individuals and records kept. Dishes were examined regularly and measurements made of the representative stages. I also made a record of the cast skins. I found that the larvæ never devour the molted skins of themselves or other specimens. I detected no evidence of cannibalism among the larvæ, even the full-grown starving specimens never attacking the much smaller individuals. Practically all of the larvæ shed their skins shortly after being deprived of food, but the molting process from this on was very much slower. The measurements showed in all cases that the different larvæ decreased in size about one-half their normal length after eight months of life at a temperature of 70 degrees and in ordinary daylight. The newly hatched began to die when about three months old. The larvæ of the middle stage up to the adult stage were all still surviving, and judging from existing circumstances, the survival, especially of the full-grown larvæ, would be considerably over one year. Experiments were carried on with reference to different kinds of diets or foods taken from the collar, as rye seed, rye straw and leather, and in drawing comparisons it was found that they thrived and grew rapidly upon the rye seed, but refused any of the other materials contained in the make-up of the collar.

CONTROL MEASURES.

HEAT.

I first took the trouble to look over the field of available literature relative to the control of this class of insects. I found that the French were the first to know the value of heat, and to devise contrivances for the heating of infested buildings. Experiments were made by Professor Webster to ascertain the amount of heat required to destroy the Angoumois grain moth, which gave the following results:

"A temperature of 140 degrees continued for nine hours literally cooks the larvæ or pupæ, a temperature of 130 degrees for five hours is fatal, as is also 120 degrees for four hours, while 110 for six hours was only partially effective."

It was also found that wheat could be subjected to a temperature of 150 degrees for eight hours without impairing its germinating properties. In the second report of the state entomologist of New York, Prof. J. A. Lintner, speaking of *Tribolium ferrugineum* infesting grain and flour, says:

"A moderate degree of heat, 120 to 130 degrees, continued for a few hours would in all probability suffice to kill all the eggs, larvæ and pupæ in the material, while a higher temperature, perhaps 150 degrees or more, would be needed for the beetles."

Professor Chittenden, in his paper on "Insects Injurious to Stored Grain," states:

"Prior to the adoption of carbon disulphide as a fumigant, heat was relied upon in the destruction of these insects. A temperature of from 125 degrees to 140 degrees Fahrenheit continued for a few hours is fatal to grain insects and wheat can be subjected to a temperature of 150 for a short time without destroying its germinating power."

A large number of the experiments of this nature were made relative to the discovery of a method to destroy grain moth, and from the results of these experiments many of the grain insects could probably be destroyed in the same manner, but it would require a higher temperature to destroy the adults than the larvæ or pupæ.

In the first experiment about thirty of the adults and larvæ were placed in a Petri dish which contained rye seed. A thermometer was placed in the vial, with the bulb resting in the middle of the rye, in the Petri dish containing the rye grain and various stages of *Trogoderma inclusa*. The Petri dish was then placed in a dry-heat oven. The bottom and surface of the interior of the oven was covered with asbestos, and the Petri dish was placed upon it, to allow uniform heating. The heat of the oven was raised to 86 degrees Fahrenheit before proceeding with the experiment. No change was noted in the action of the insects. At a temperature of 100 degrees the adults and larvæ began to crawl out of the grain; at a temperature of 110 degrees both larvæ and adults manifested excessive excitement, and were making every effort to escape. They continued to be quite active until the temperature of 115 degrees was reached. At this temperature the adults and larvæ became less active, and at a temperature of 118 degrees the adults were all dead, and also a large number of the larvæ. At a temperature of 119 degrees there was no sign of life. To be sure that I had killed all of

the insects, I raised the temperature to 120 degrees, and then the insects were removed and placed in an incubator and given a chance to recover, but the test showed finally that they were all dead. I repeated the experiment a number of times, and found that as soon as a temperature of from 119 to 120 degrees was recorded it proved fatal to all stages of the insect. It required about thirty minutes to reach this temperature.

In a second series of experiments I continued to use the dry-heat oven, again raising the temperature to 86 degrees. I then took one of the infested horse collars and made a hole in the leather, through which I inserted the bulb of a thermometer into the interior of the stuffing. The collar was then placed in the oven on an asbestos floor to allow equal heating. The temperature was gradually raised to 120 degrees, which took about ten hours. After leaving the collar in the oven for a period of ten hours it was removed and placed in the incubator to allow a chance for the insects to develop again. A day or two following I removed the collar and proceeded to make a thorough dissection of it. I found that the larvæ and adults were all dead. Upon further incubation of the straw stuffing it was found that the eggs had also been destroyed by the maximum temperature, as no more of the insects were hatched.

After demonstrating in the laboratory by experiments that this species of insect could be destroyed at a temperature below that which would be injurious to the leather of the horse collars, steps were taken to test out its results as to the practibility in a seriously infested collar factory overrun with *Trogaderma inclusa,* of the results which were demonstrated in the laboratory.

The means of extermination was left in the hands of the experimenter. The collar warehouse was the only infested floor, and it was located on the sixth floor of the factory. The heating facilities were too inadequate to produce the temperature required to exterminate the infestation; hence, according to instruction, a small room, twelve feet long, eight wide and twelve high, was constructed, and lined on the interior with asbestos. Two large steam-heat radiators were installed, and the collars hung on brackets about the room. One large thermometer was placed in the room and several smaller ones inserted in the collars. The results of this work proved successful.

In this experiment also two thermometers were employed. One was placed in a collar and the other in the chamber. By recording the temperatures at short intervals and plotting them on a chart,

it was evident that the temperature rise in the collar lagged behind that of the chamber. This lag increased as the temperature rose until at 122° F., there was a difference of nearly two hours. Thus the steam was turned into the radiators at 8 a. m. and while the chamber temperature reached 122° F. at about 4 p. m. the collar temperature did not reach this until 6 p. m.

COLD.

A temperature control machine such as is used by this department was used to demonstrate the possibilities of a freezing temperature as a factor in the means of exterminating the pest. A number of the specimens were placed in a vial in the temperature machine. The temperature was reduced to two degrees below zero and held constant for ten hours. The larvæ were apparently dead but after a short period of incubation the specimens began to be active again. I did not continue the experiments, as I realized the impracticability of this means of extermination.

CARBON DISULPHIDE.

Carbon disulphide is a foul-smelling liquid that volatilizes readily at ordinary temperature, and produces a heavy vapor that is deadly to insects of all kinds when they are confined in a closed space and must breathe it. In reading the data of the various books and bulletins at hand on fumigation, it was found that this gas is especially useful against species infesting stored grains and mills etc., overrun with Dermestidæ, moth, and so on. There was reason to believe, then, that the insects within the collars could be exterminated if the carbon disulphide could be properly administered to the interior of the collar.

I made a carbon disulphide extermination test of the *Trogoderma inclusa* as they occurred in the horse collars. I prepared a box for inclosing one of the collars by covering it with paper on the inside, and closing it with a tight cover. A small amount of carbon disulphide was injected into the collar by means of a specially devised syringe. The syringe used is modeled after the ordinary type with the exception that a nozzle about four inches in length was devised to reach all parts of the interior of the collar. The instrument is made of steel for durability and strength, as considerable force is required in making the insertion. The nozzle of the syringe was inserted in the collar stuffing, entrance being made between the seams; thus there was no injury to the collar. It was injected at spaces of about four or five inches apart. From six to

eight drams were injected into each collar. The collar was then inclosed in the box and left for twenty-four hours. After making a thorough dissection of the collar, the various larval stages found were all dead, and upon incubation no evidence of recovery was noted in any of the larvæ or adults.

HYDROCYANIC-ACID GAS.

Hydrocyanic-acid gas is a vapor very destructive to all life. The gas is produced by adding potassium cyanide to sulphuric acid. I used these in the following proportions:

Potassium cyanide, 98 per cent pure	1 oz.
Sulphuric acid, specific gravity 1.83	2 oz.
Water	4 oz.

I placed several of the infested collars in a closed chemistry hood. I put an earthen vessel inside, containing water, poured the sulphuric acid slowly in the water, and then added the potassium cyanide, and immediately closed the hood and left the collars exposed to the hydrocyanic acid for two hours, and then opened the hood and let the gas escape. I then took the collars from under the hood and examined the stuffing. There was no trace of life or recovery of the insects in the different stages.

SUMMARY AND CONCLUSION.

The *Trogoderma inclusa* discussed in this paper were found in horse collars that were sent to this department, requesting our advice and assistance in determining the kind and source of infestation and measures to be used in the control of this damaging insect.

With regard to the source of infestation: Upon opening the collars and finding grain in the straw stuffing, and upon examination of the grain in many instances, I noted that it had been eaten upon by the larvæ of this insect, and through the instrumentality of my series of investigations in relation to the life history, I found that they thrived much better upon the grain than any other material found in the make-up of the collars. This gave me a clue as to the source of infestation. After getting some of the stored unthreshed rye, and some of the rye seed which had been stored where it had been raised, I found that a series of incubations produced exactly the same species that was found in the collars.

In considering the matter of infestation and the measures to be used for its control, I suggest that the grain be eliminated as nearly as possible from the straw to be used in the stuffing of the collars, and there will be no liability of serious infestation. However, as I

have experienced personally and through correspondence, many of the people engaged in the manufacture of horse collars are not aware of the value of clean-threshed straw, the seed of which forms an abundant food supply for these insects, and thus follows the dilemma caused by the infestation. Applicable to such cases, I have performed a series of experiments to demonstrate their relative value concerning the means of extermination. Experiments were carried on with heat and cold temperatures and carbon disulphide and hydrocyanic-acid gases, and in conclusion I feel at liberty to state that heat is to be preferred as the best means of control. It insures extermination, and is by far the most economical as well as the safest means of eradicating the infestations.

With reference to the matter of multiplicity and distribution of this species of insect, it was found to be a rare species generally distributed over the the United States and Europe, and is omnivorous in its feeding habits. I found this species to thrive and develop much more rapidly upon seeds and grain foods than any other available material which I had at hand for testing out the food habits.

In making a summary of the variations of the life history of a number of individuals of the same generation, I noted:

1. The adults oviposit from four to six days after emergence.
2. The number of eggs laid by different individuals varied from ten to forty-five.
3. The eggs hatch in from eight to twelve days at ordinary room temperature.
4. The larval life lasts about five months, on the average.
5. The time of pupation is from ten to fourteen days.
6. The adult lives from eight to twenty-five days.

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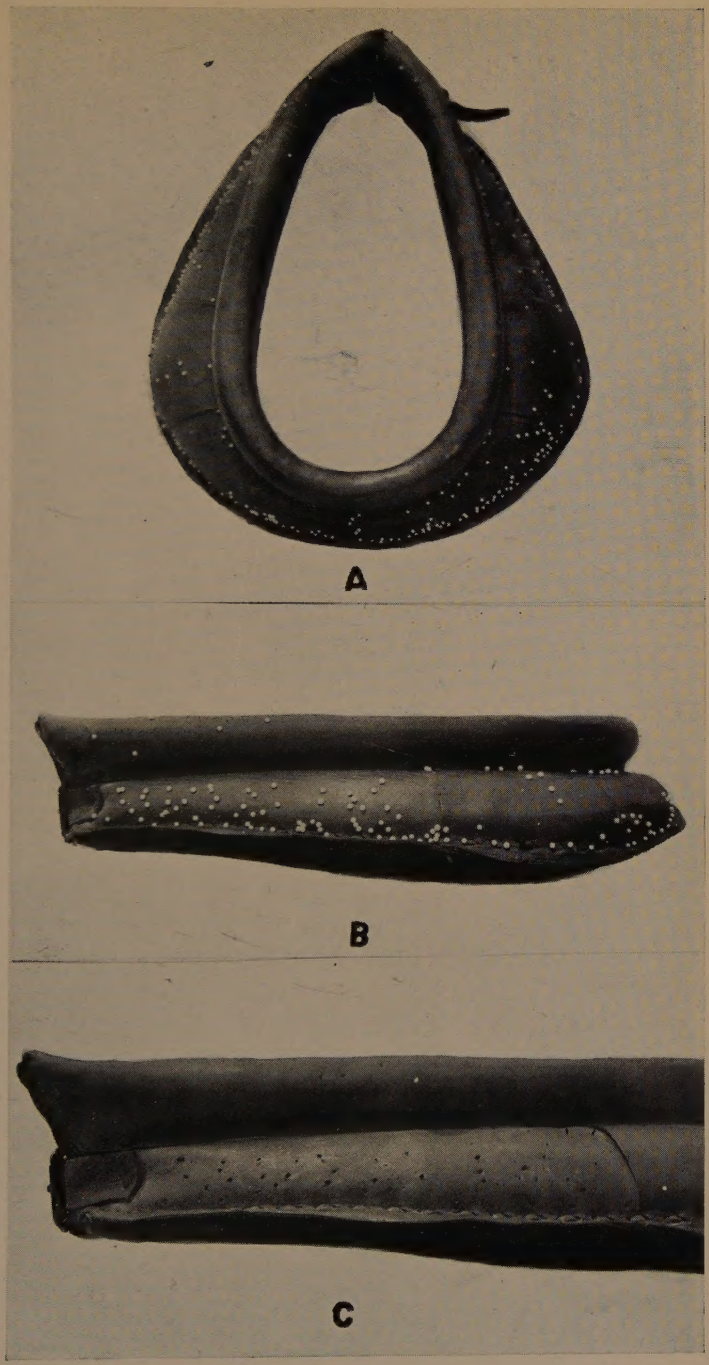
PLATE XXXIX.

Photographs of leather horse collars damaged by the dermestid *Trogoderma inclusa* Lec. In figures A and B, white-headed pins were inserted to indicate the position of the holes made by emerging beetles. Figure C shows the exit holes made by the beetles.



Photographs by P. A. Readio.

PLATE XL.

Trogoderma inclusa Lec.

1. Ventral view of beetle.
2. Dorsal view of beetle.
3. Ventral view of pupa.
4. Eggs.
5. Antennæ.
6. Ventral view of larva.
7. Pupa.
8. Dorsal view of larva.

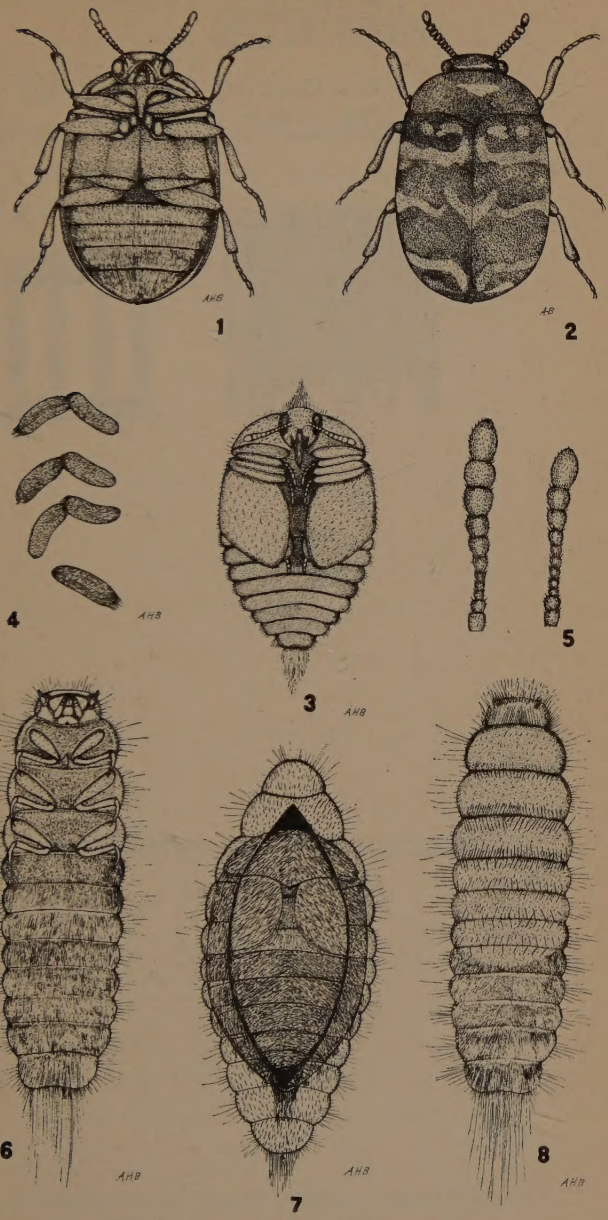



PLATE XL.